NASA Electronic Parts and Packaging Program (NEPP)

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FY01 Proposal Format

Title: Evaluation of Alignment Tolerant Optoelectronic Structures
(check one): ☐ New Proposal **X Continuing NEPP Work (Year 2)**
Total $ Requested for FY01: $225,000
Technology Type: ☐ Newly Available (COTS) **X** Emerging/Advanced
(check one)
Project Area: Parts **X** Packaging Radiation
(check one)
Proposing Centers: Center A (GSFC) JPL
Participating Center(s): **70**% GSFC **30 % JPL**
(Estimated Center Participation, %$):
Collaborators: **JPL, University of MD, Swales Aerospace**
Point of Contact: Harry C Shaw
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Investigator:

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Objective(s):

Continuation of FY00 Activities to evaluate alignment tolerant optoelectronic structures fabricated by University of MD
Demonstrate their performance as a lossless optical splitter
Demonstrate these devices as a Mach-Zehnder Interferometer

Task Description:

The requirement to achieve a high degree of laser-fiber alignment is a driving factor in the efficiency of fiber coupled laser microelectronics. An alignment tolerant structure is an inexpensive method to reduce coupling losses and improve end-to-end efficiency of a fiber optic system. This is very important in space based fiber optic systems which may suffer from alignment induced losses which cannot be subsequently corrected. GSFC and JPL will evaluate a novel approach for alignment tolerant structures for ease of alignment of optoelectronic(OE) devices to a single-mode fiber.

Task Approach to Meeting NEPP Objectives: The increasing functionality and complexity of Optoelectronic (OE) devices is driving the need for large scale and low-low cost assembly of OE components and modules. There has been an increased interest in hybrid and monolithic integration of OE devices to obtain high speed, high functionality and reliable fiber optics modules. Performance of the work under this task accelerates the infusion of alignment tolerant structures in fiberized high performance optoelectronic applications.

Technical Background: This work will leverage off of the funding he University of Maryland has invested in the development of adiabatic vertical mode transformers that do not necessitate regrowth[1,2]. They have demonstrated a large mode laser at 1550 nm using two vertically placed waveguides where the top waveguide is the highly confined active waveguide and the bottom waveguide is a large loosely confined passive waveguide. The mode is pushed from the top waveguide to the underlying waveguide adiabatically by tapering the top waveguide slowly as shown in Fig. 1. The results have been good butt-coupling efficiencies to single mode fibers with relaxed alignment tolerances making these devices suitable for hybrid integration using passive packaging.

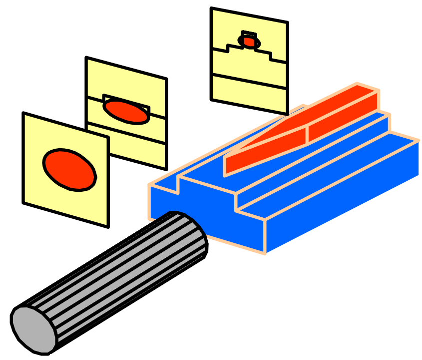

Fig. 1. Schematic of the adiabatic mode expander

We will also evaluate a new approach (patent pending) that relies on resonant vertical coupling of two supermodes of the waveguide that has already been demonstrated. This will permit the implementation of much more compact mode transformers than what has been demonstrated so far. We have demonstrated a low-loss mode expander with mode transformation region as short as 200 µm. This is the shortest transformation region reported and is about 3 times shorter than the corresponding adiabatic mode transformers. This not only allows for compact devices but also high-speed operation. In addition, the above transformation scheme allows a new very powerful approach to monolithically integrate different OE devices on the same substrate. The two vertically placed waveguides can be optimized for different optical functions with different bandgaps.

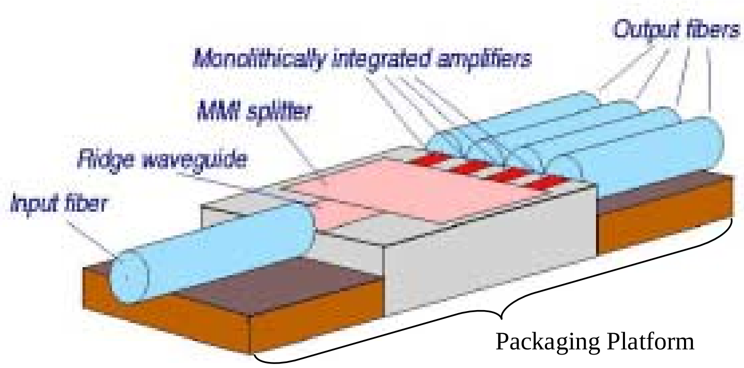

Fig. 3. Schematic of a packaged lossless

Technical Approach: By transforming the mode between the waveguides, various OE integrated modules like lasers and modulators, semiconductor amplifiers and splitters, optical switches and passive waveguides, can be built. Two applications will be demonstrated and evaluated. In one approach, one of the waveguides will be optimized for gain, and the second waveguide can be optimized for passive devices like splitter. In this way, by pushing the mode into the active waveguide and giving it gain we can make loss-less splitters as shown in Fig. 3. In the second approach, a Mach-Zehnder interferometer with integrated amplifiers for high speed wavelength conversion, will be fabricated and evaluated. The fabrication activities will be conducted by the University of Md. Packaging activities will be performed by the University of Md and GSFC. Test and evaluation will be performed by University of Md, GSFC and JPL. Significant support is expected from JPL (Dr. Siamak Forourhar)

NASA Customers: We expect that the development of this innovative generic OE integration technology will be of benefit to all of the NASA strategic enterprises. In particular, it will find applications in the transport of high-speed communication signals via fiber-optics links. The Mach Zehnder is an especially important component in wavelength conversion and electrooptical modulators. These devices are important components in the development of RF-Optical links that will permit transmission of wideband microwave signals over fiber links. This generic technology will benefit both the Goddard Space Flight Center and JPL via their Space Science and Mission to Planet Earth Strategic enterprises (MTPE). This technology will most likely also have appeal to the Langley Space Center via its atmospheric science program in the MTPE enterprise, in the Marshall Space Flight Center via its program on space transportation systems and to the Kennedy Space Center via its program in space launch.

Clearly Stated Deliverables:

Test Units
Specifications for Optical lossless splitter and Mach-Zehnder Interferometer
Evaluation and test reports
Failure Analysis Reports

Top Level Schedule: **This schedule assumes that we receive funding FY00 funding in 1st qtr FY00**

FY01/Q1	Define performance characteristics and test/evaluation plan for Optical lossless splitter. Purchase components
FY01/Q2	Begin fabrication
FY01/Q3	Complete fabrication , begin testing
FY01/Q4	Complete initial test and evaluation. Prepare follow-on test plan
FY02/Q1	Define performance characteristics and test/evaluation plan for Optical lossless splitter. Purchase components
FY02/Q2	Begin fabrication
FY02/Q3	Complete fabrication, begin testing
FY02/Q4	Complete initial test and evaluation. Prepare follow-on test plan

Leveraging: This work will leverage off of the funding he University of Maryland has invested in the development of adiabatic vertical mode transformers.

References:

1) V. Vusirikala, S.S. Saini, R.E. Bartolo, R. Whaley, S. Agarwala, F.G. Johnson, D.R. Stone and M. Dagenais, "High butt-coupling efficiency to single mode fibers using a 1.55 mm InGaAsP laser integrated with a tapered ridge mode transformer," *IEEE Phot. Tech. Lett.*, vol. 9, No. 11, pp. 1472-1474, November 1997.

2) V. Vusirikala, S.S. Saini, R.E. Bartolo, S. Agarwala, R.D. Whaley, F.G. Johnson, D.R. Stone and Dagenais, "1.55-μm InGaAsP-InP Laser Arrays with Integrated-Mode Expanders fabricated using single epitaxial growth," *IEEE J. Select. Topics. Quantum. Electron.*, vol. 3, no.6, pp 1332-1343, December 1997.